US011259125B2

(12) United States Patent
Lee et al.

(10) Patent No.: US 11,259,125 B2
(45) Date of Patent: Feb. 22, 2022

(54) **MEMS MICROPHONE AND METHOD OF MANUFACTURING THE SAME**

(71) Applicant: **DB HITEK CO., LTD.**, Seoul (KR)

(72) Inventors: **Han Choon Lee**, Seoul (KR); **Hyeok In Kwon**, Gyeonggi-do (KR); **Jong Won Sun**, Gyeonggi-do (KR); **Dong Chun Park**, Incheon (KR); **Ye Eun Na**, Seoul (KR)

(73) Assignee: **DB HITEK CO., LTD.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 17 days.

(21) Appl. No.: **16/842,303**

(22) Filed: **Apr. 7, 2020**

(65) **Prior Publication Data**

US 2020/0322732 A1 Oct. 8, 2020

(30) **Foreign Application Priority Data**

Apr. 8, 2019 (KR) 10-2019-0040565

(51) **Int. Cl.**
H04R 19/04 (2006.01)
H04R 31/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H04R 19/04*** (2013.01); ***H04R 31/00*** (2013.01); *H04R 2410/03* (2013.01)

(58) **Field of Classification Search**
CPC . H04R 19/00; H04R 19/005; H04R 2201/003
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,590,136	B2 *	11/2013	Yang	H04R 19/005 29/594
9,382,109	B2 *	7/2016	Johansen	H04R 31/00
9,630,837	B1 *	4/2017	Chu	B81B 3/0021
9,888,324	B2 *	2/2018	Hu	H04R 7/20
9,967,679	B2 *	5/2018	Krumbein	B81B 7/02
9,980,052	B2 *	5/2018	Johansen	H04R 19/005
10,065,852	B2 *	9/2018	Cheng	H04R 19/04
10,250,998	B2 *	4/2019	Hsieh	H04R 31/003

(Continued)

FOREIGN PATENT DOCUMENTS

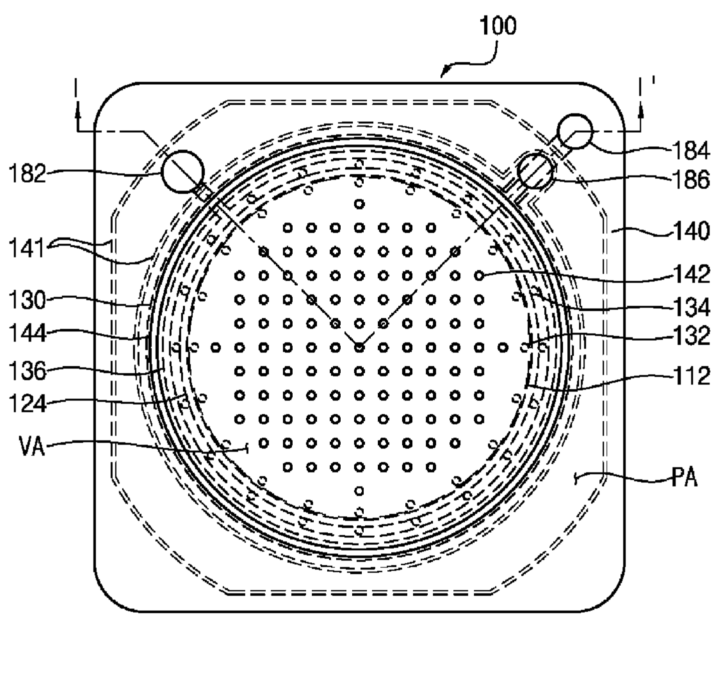
CN 103281659 A * 9/2013

Primary Examiner — Ryan Robinson
(74) *Attorney, Agent, or Firm* — Patterson Thuente Pedersen, P.A.

(57) **ABSTRACT**

A MEMS microphone includes a substrate presenting a vibration area, a supporting area surrounding the vibration area and a peripheral area surrounding the supporting area, the substrate defining a cavity formed in the vibration area, a lower back plate being disposed over the substrate to cover the cavity and having a plurality of lower acoustic holes, a diaphragm being disposed over the lower back plate, the diaphragm being spaced apart from the lower back plate and configured to generate a displacement thereof in response to an applied acoustic pressure, an upper back plate being disposed over the diaphragm, the upper back plate being spaced apart from the diaphragm and having a plurality of upper acoustic holes, and an intermediate anchor being in contact with an upper surface of the lower back plate in the supporting area, the intermediate anchor being configured to support the diaphragm to space the diaphragm from the lower back plate, and to provide elasticity for the diaphragm.

19 Claims, 8 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

10,405,099	B2 *	9/2019	Jost	B81B 7/0006
10,419,858	B2 *	9/2019	Ravnkilde	B81B 3/0072
10,506,345	B2 *	12/2019	Klein	H04R 23/00
10,589,987	B2 *	3/2020	Wiesbauer	H04R 1/406
10,766,763	B2 *	9/2020	Lin	B81B 3/0021
10,981,780	B2 *	4/2021	Klein	B81B 3/0021
10,993,043	B2 *	4/2021	Lee	H04R 1/406
2015/0264462	A1 *	9/2015	Okugawa	H04R 19/04 381/174
2015/0289046	A1 *	10/2015	Dehe	H04R 1/08 381/111
2017/0156008	A1 *	6/2017	Rasmussen	H04R 31/006
2020/0290864	A1 *	9/2020	Fueldner	H04R 23/00

* cited by examiner

FIG. 1

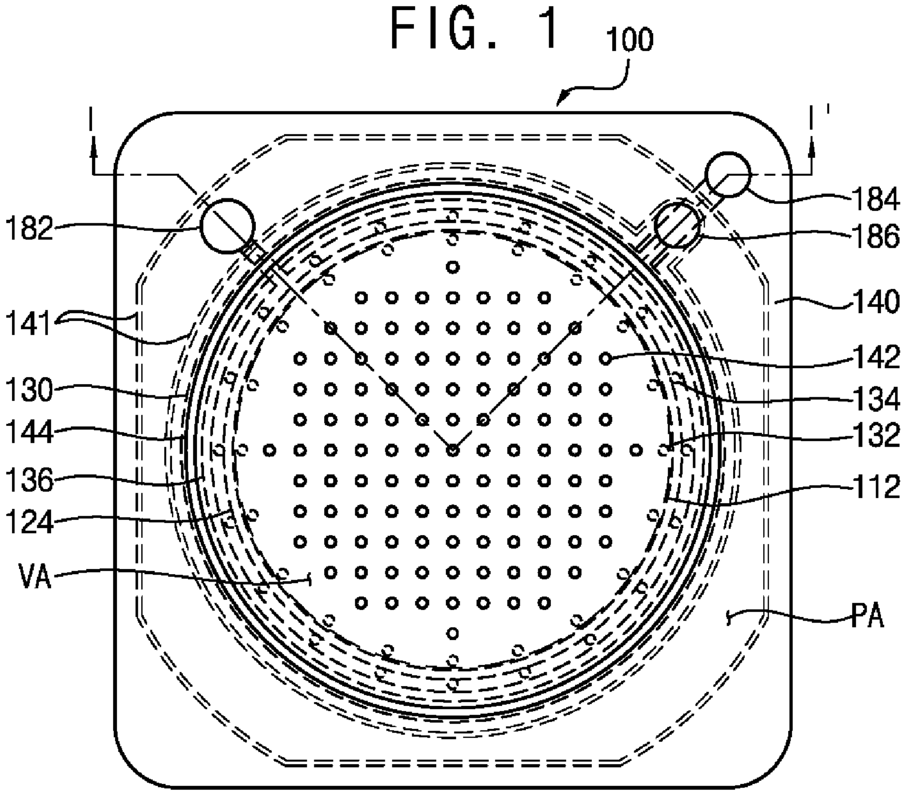

100
182
184
186
141
140
142
130
134
144
132
136
112
124
VA
PA
I
I'

FIG. 2

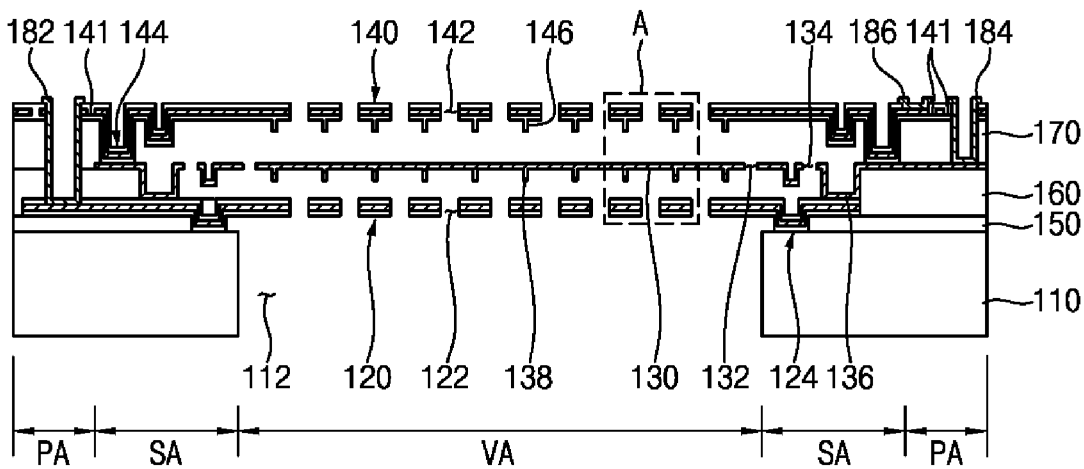

182
141
144
140
142
146
A
134
186
141
184
170
160
150
110
112
120
122
138
130
132
124
136
PA
SA
VA
SA
PA

FIG. 3

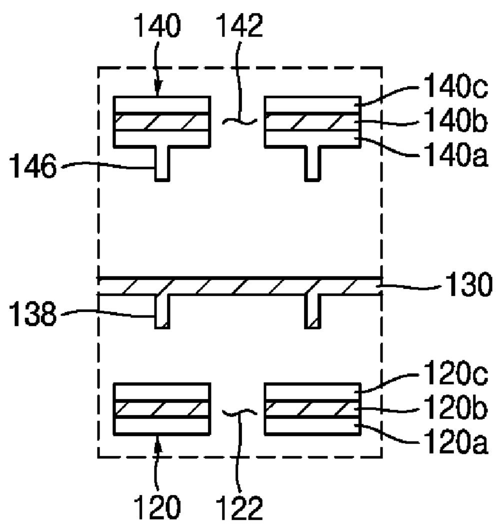


FIG. 4

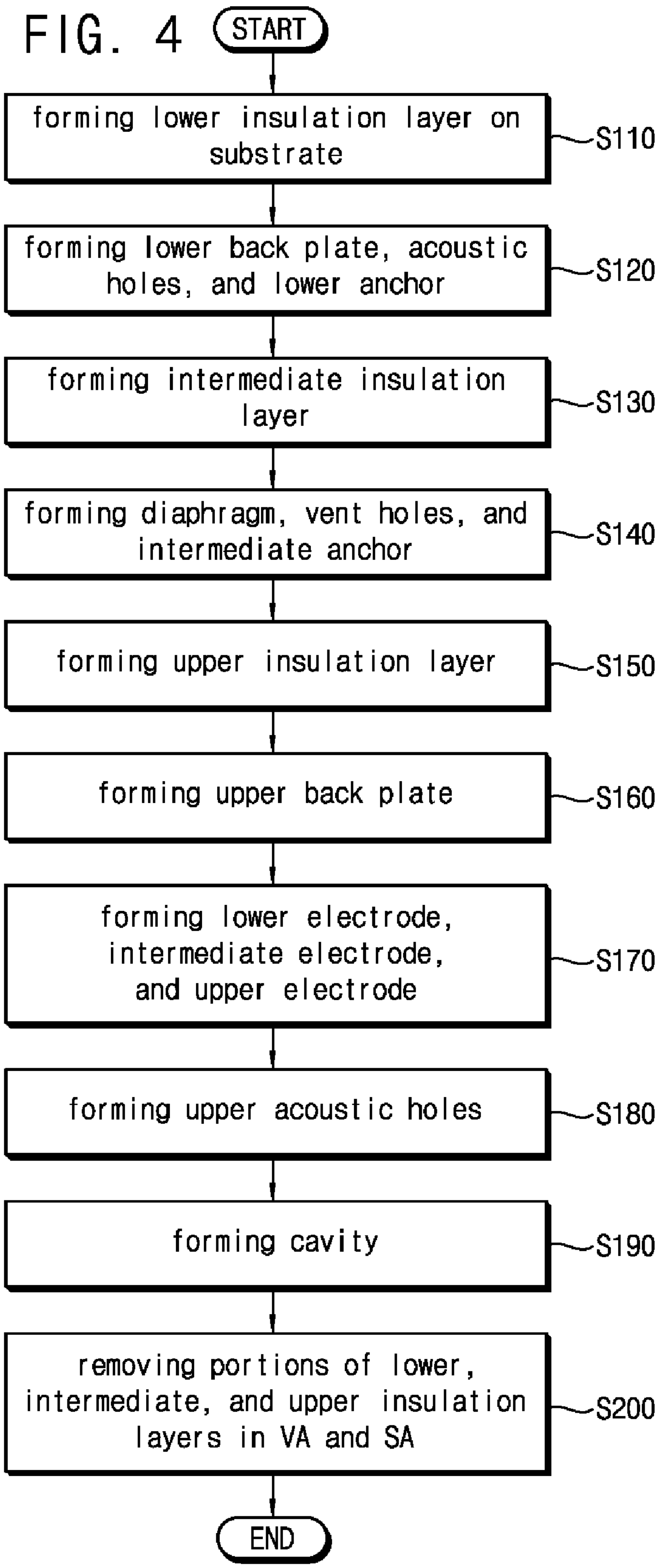

START
forming lower insulation layer on substrate
S110
forming lower back plate, acoustic holes, and lower anchor
S120
forming intermediate insulation layer
S130
forming diaphragm, vent holes, and intermediate anchor
S140
forming upper insulation layer
S150
forming upper back plate
S160
forming lower electrode, intermediate electrode, and upper electrode
S170
forming upper acoustic holes
S180
forming cavity
S190
removing portions of lower, intermediate, and upper insulation layers in VA and SA
S200
END

FIG. 5

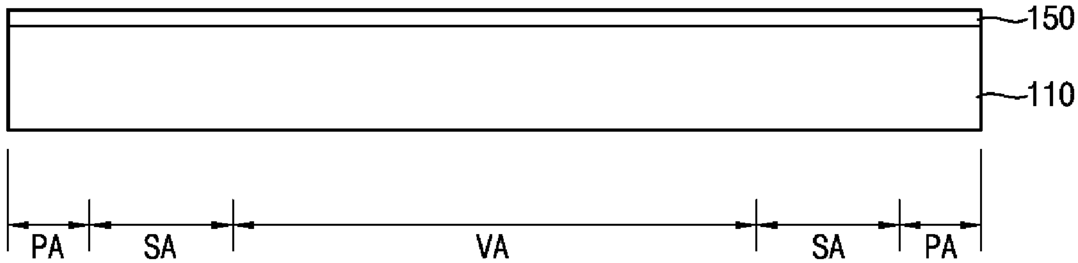


FIG. 6

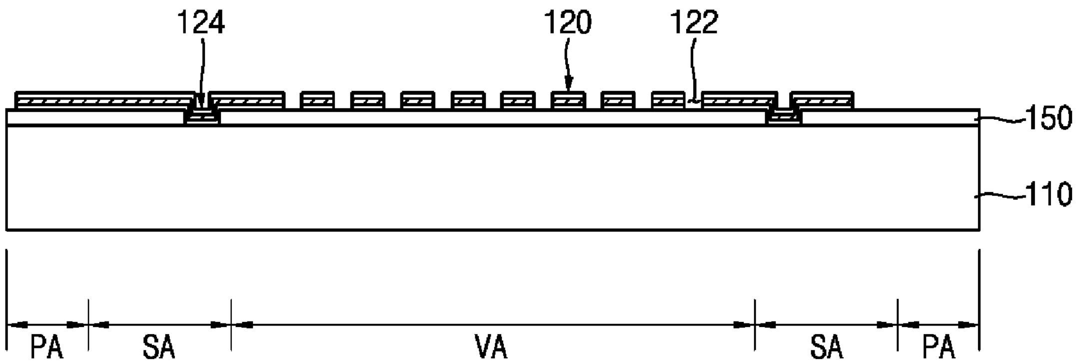


FIG. 7

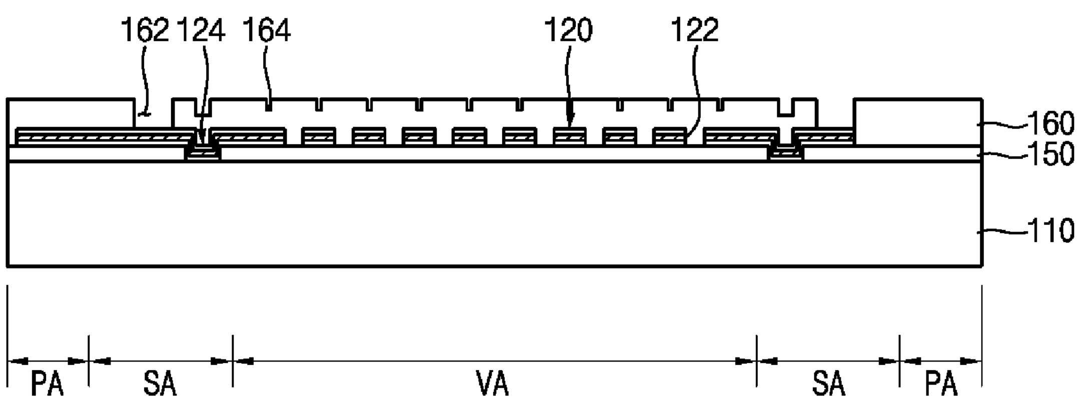


FIG. 8

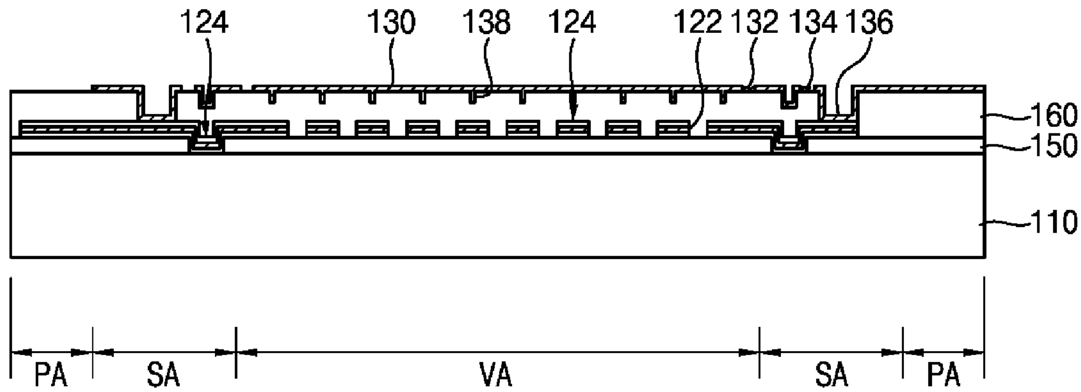

124
130
138
124
122
132
134
136
160
150
110
PA
SA
VA
SA
PA

FIG. 9

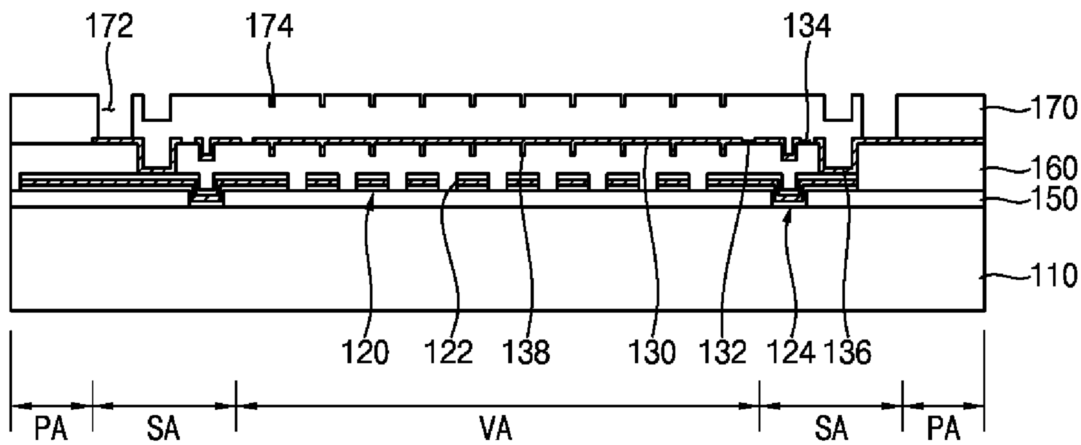

172
174
134
170
160
150
110
120
122
138
130
132
124
136
PA
SA
VA
SA
PA

FIG. 10

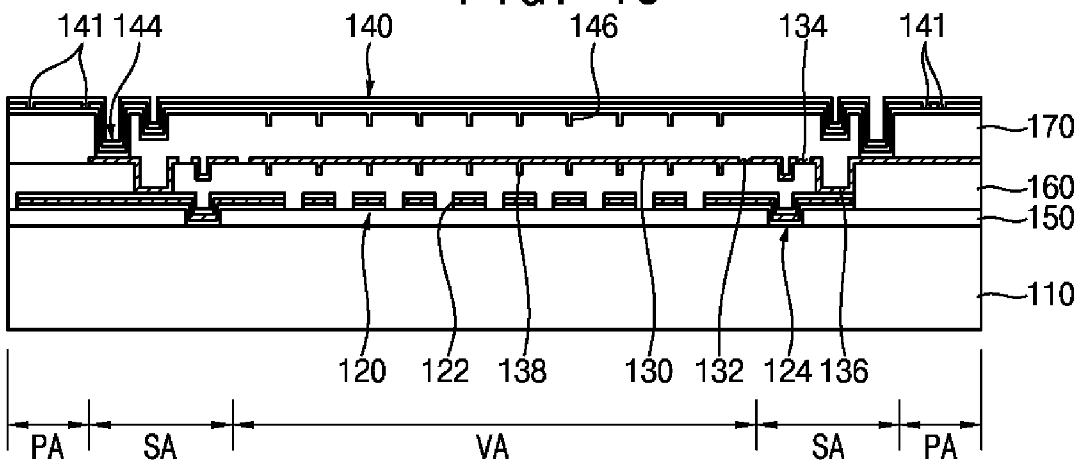

141 144
140
146
134
141
170
160
150
110
120
122
138
130
132
124
136
PA
SA
VA
SA
PA

FIG. 11

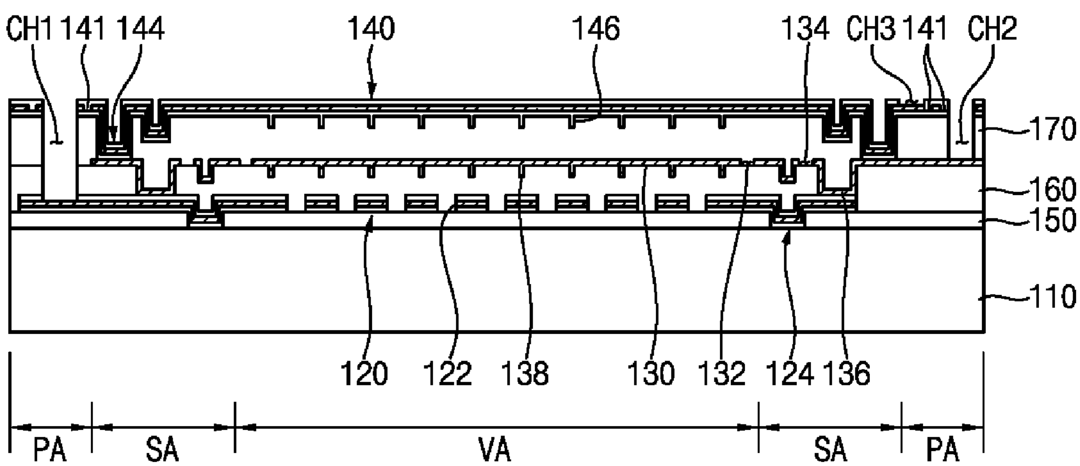

CH1 141 144
140
146
134
CH3 141
CH2
170
160
150
110
120
122
138
130
132
124
136
PA
SA
VA
SA
PA

FIG. 12

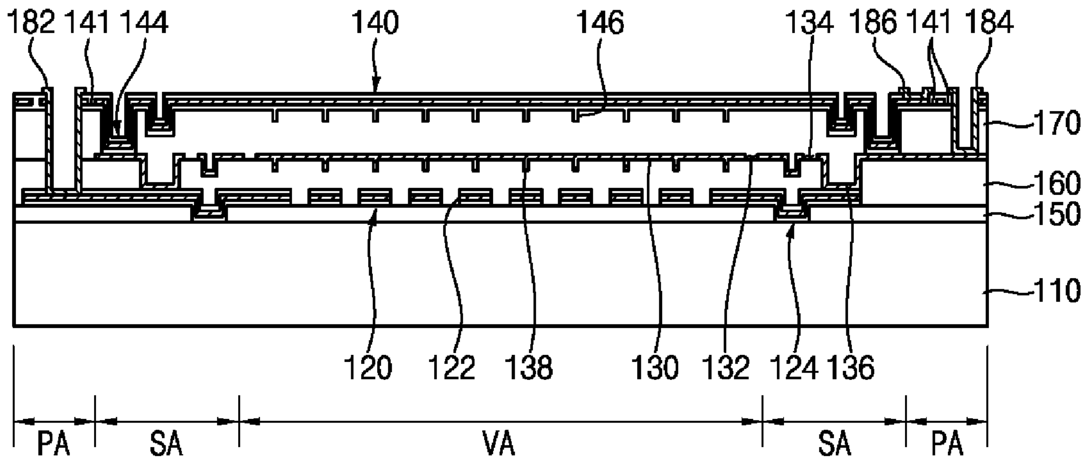

182
141
144
140
146
134
186
141
184
170
160
150
110
120
122
138
130
132
124
136
PA
SA
VA
SA
PA

FIG. 13

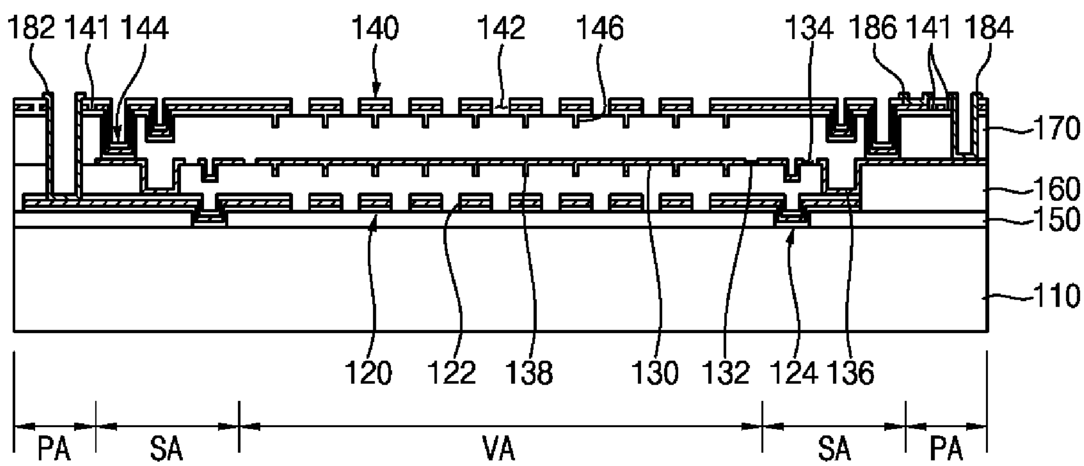

182
141
144
140
142
146
134
186
141
184
170
160
150
110
120
122
138
130
132
124
136
PA
SA
VA
SA
PA

FIG. 14

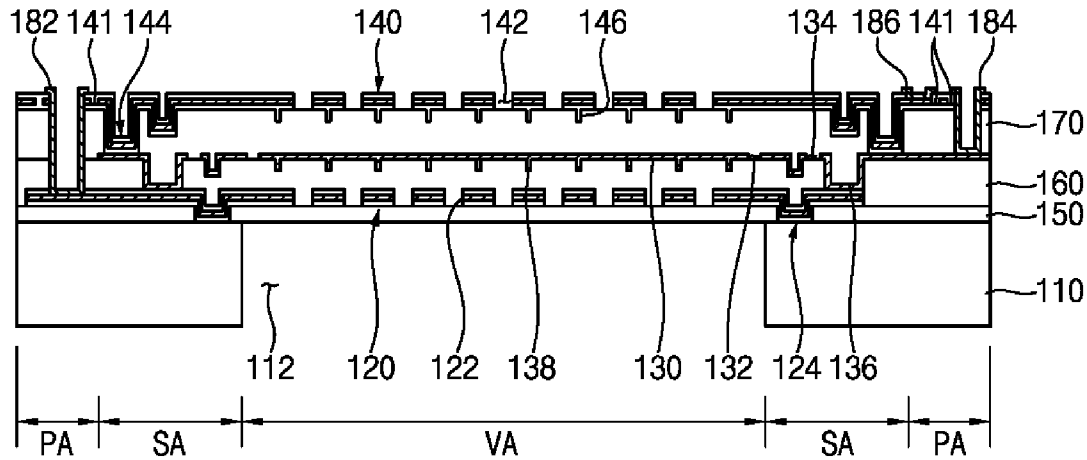
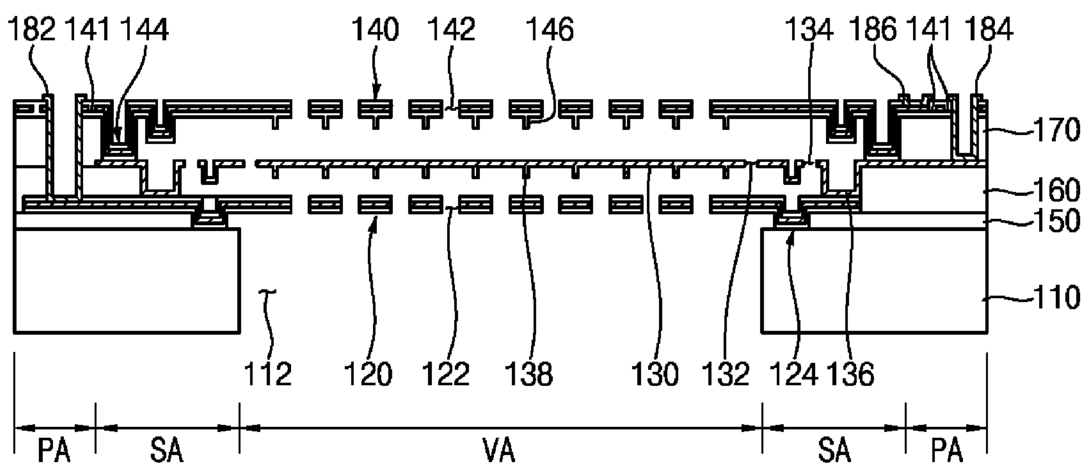

182 141 144
140
142
146
134 186 141 184
170
160
150
110
112
120
122
138
130
132
124 136
PA
SA
VA
SA
PA

FIG. 15


182 141 144
140
142
146
134 186 141 184
170
160
150
110
112
120
122
138
130
132
124 136
PA
SA
VA
SA
PA

MEMS MICROPHONE AND METHOD OF MANUFACTURING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to Korean Patent Application No. 10-2019-0040565, filed on Apr. 8, 2019, and all the benefits accruing therefrom under 35 U.S.C. § 119, the contents of which are incorporated by reference in their entirety.

TECHNICAL FIELD

The present disclosure relates to Micro-Electro-Mechanical Systems (MEMS) microphones capable of converting an acoustic wave into an electrical signal, and a method of manufacturing such MEMS microphones, and more particularly, to capacitive MEMS microphones that are capable of transmitting signals related to an acoustic signal using a displacement which may be generated due to an acoustic pressure and a method of manufacturing such MEMS microphones.

BACKGROUND

Generally, a capacitive microphone utilizes a capacitance between a pair of electrodes which are facing each other to generate an electrical signal indicative of an incoming acoustic wave. A MEMS microphone may be manufactured by a semiconductor MEMS process.

In order to apply the MEMS microphone to a mobile device such as a mobile phone, the signal-to-noise ratio (SNR) of the MEMS microphone must be improved.

In order to improve the SNR of the MEMS microphone, the MEMS microphone may include a bendable diaphragm and double back plates which are facing the diaphragm.

However, each of the diaphragm, the back plates, and insulation layers supporting the diaphragm and the back plates has a flat plate shape. Therefore, a flexibility of the diaphragm may be poor, and the sensitivity and the SNR of the MEMS microphone can be relatively low.

SUMMARY

The embodiments of the present invention provide a MEMS microphone capable of improving a sensitivity and a SNR of the MEMS microphone, and a method of manufacturing the MEMS microphone.

According to an example embodiment of the present invention, a MEMS microphone includes a substrate presenting a vibration area, a supporting area surrounding the vibration area and a peripheral area surrounding the supporting area, the substrate defining a cavity formed in the vibration area, a lower back plate being disposed over the substrate to cover the cavity and having a plurality of lower acoustic holes, a diaphragm being disposed over the lower back plate, the diaphragm being spaced apart from the lower back plate and configured to generate a displacement thereof in response to an applied acoustic pressure, an upper back plate being disposed over the diaphragm, the upper back plate being spaced apart from the diaphragm and having a plurality of upper acoustic holes, and an intermediate anchor being in contact with an upper surface of the lower back plate in the supporting area, the intermediate anchor being configured to support the diaphragm to space the diaphragm from the lower back plate, and to provide elasticity for the diaphragm.

In an example embodiment, the MEMS microphone may further include a lower anchor being in contact with an upper surface of the substrate in the supporting area, the lower anchor being configured to support the lower back plate to space the lower back plate from the substrate, and an upper anchor being in contact with an upper surface of the diaphragm in the supporting area, the upper anchor being configured to support the upper back plate to space the upper back plate from the diaphragm,

In an example embodiment, the MEMS microphone may further include a lower insulation layer disposed on the upper surface of the substrate and outside of the lower anchor, and being configured to support the lower back plate, an intermediate insulation layer disposed on an upper surface of the lower insulation layer and outside of the intermediate anchor, and being configured to support the diaphragm, and a upper insulation layer disposed on an upper surface of the intermediate insulation layer and outside of the upper anchor, and being configured to support the upper back plate.

In an example embodiment, the MEMS microphone may further include a lower electrode penetrating through the upper insulation layer and the intermediate insulation layer and being disposed in the peripheral area to make electrically contact with the lower back plate, an intermediate electrode penetrating through the upper insulation layer and being disposed in the peripheral area to make electrically contact with the diaphragm, and an upper electrode being disposed in the peripheral area and making electrically contact with the lower back plate.

In an example embodiment, each of the lower back plate and the upper back plate includes a conductive layer and insulation layers disposed on an upper surface and a lower surface of the conductive layer.

In an example embodiment, the upper insulation layer included in the upper back plate includes a pair of protrusion portions protruding from a lower surface of the upper insulation layer and penetrating through the conductive layer to make contact with the lower insulation layer included in the upper back plate, and wherein the protrusion portions divide the conductive layer into an inner area, an intermediate area surrounding the inner area, and an outer area surrounding the intermediate area.

In an example embodiment, the lower electrode makes contact with the intermediate area of the conductive layer, the intermediate electrode makes contact with the outer area of the conductive layer, and the upper electrode makes contact with the inner area of the conductive layer.

In an example embodiment, the diaphragm defines a plurality of vent holes penetrating therethrough and spaced apart from each other to be arranged along a periphery of the diaphragm,

In an example embodiment, the MEMS microphone may further include lower dimples protruding from a lower surface of the diaphragm toward the lower back plate and preventing the diaphragm from being coupled to the lower back plate, and upper dimples protruding from a lower surface of the upper back plate toward the diaphragm and preventing the upper back plate from being coupled to the diaphragm.

According to an example embodiment of the present invention, a method of manufacturing a MEMS microphone comprises forming a lower insulation layer on a substrate, the substrate having a vibration area, a supporting area surrounding the vibration area, and a peripheral area surrounding the supporting area, forming a lower back plate having a plurality of lower acoustic holes on the lower insulation layer, forming an intermediate insulation layer on the lower insulation layer on which the lower back plate is formed, forming a diaphragm and an intermediate anchor being configured to support the diaphragm on the intermediate insulation layer, respectively, forming an upper insulation layer on the intermediate insulation layer on which the diaphragm and the intermediate anchor are formed, and forming a upper back plate having a plurality of upper acoustic holes on the upper insulation layer.

In an example embodiment, forming the lower back plate includes forming a lower anchor being configured to support the lower back plate simultaneously, and forming the upper back plate includes forming an upper anchor being configured to support the upper back plate simultaneously.

In an example embodiment, the lower anchor, the intermediate anchor and the upper anchor are disposed in the supporting area, and the lower anchor is in contact with an upper surface of the substrate, the intermediate anchor is in contact with an upper surface of the lower back plate, and the upper anchor is in contact with an upper surface of the diaphragm.

In an example embodiment, the method of manufacturing a MEMS microphone may further comprise after forming the upper back plate, forming a lower electrode, an intermediate electrode, and an upper electrode in the peripheral area, and the lower electrode penetrates through the upper insulation layer and the intermediate insulation layer to make electrically contact with the lower back plate, the intermediate electrode penetrates through the upper insulation layer to make electrically contact with the diaphragm, and the upper electrode makes electrically contact with the lower back plate.

In an example embodiment, each of the lower back plate and the upper back plate includes a conductive layer and insulation layers disposed on an upper surface and a lower surface of the conductive layer.

In an example embodiment, the upper insulation layer included in the upper back plate includes a pair of protrusion portions protruding from a lower surface of the upper insulation layer and penetrating through the conductive layer to make contact with the lower insulation layer included in the upper back plate, and wherein the protrusion portions divide the conductive layer into an inner area, an intermediate area surrounding the inner area, and an outer area surrounding the intermediate area.

In an example embodiment, the lower electrode makes contact with the intermediate area of the conductive layer, the intermediate electrode makes contact with the outer area of the conductive layer, and the upper electrode makes contact with the inner area of the conductive layer.

In an example embodiment, the method of manufacturing a MEMS microphone may further comprise, after forming the lower electrode, the intermediate electrode, and the upper electrode, patterning the upper back plate to form upper acoustic holes penetrating the back plate, patterning the substrate to form a cavity exposing the lower insulation layer to the vibration area, and performing an etching process using the cavity, the lower acoustic holes, and the upper acoustic holes to remove portions of the lower insulation layer and the intermediate insulation layer, located at positions corresponding the vibration area and the supporting area so that the diaphragm is bendable by acoustic pressure.

In an example embodiment, forming the diaphragm and the intermediate anchor includes forming a plurality of vent holes penetrating through the diaphragm simultaneously with the diaphragm and the intermediate anchor, and the vent holes are formed on the vibration area.

In an example embodiment, the vent holes serve as passages for the etchant to remove the portions of the lower insulation layer and the intermediate insulation layer during the etching process.

According to example embodiments of the present invention as described above, the MEMS microphone includes the intermediate anchor supporting the diaphragm and having a bent shape so that the diaphragm can be elastically supported by the intermediate anchor. Since flexibility of the diaphragm can be remarkably improved without reducing rigidity of the diaphragm as compared with conventional MEMS microphone, sensitivity of the diaphragm can be improved and sagging of the diaphragm can be prevented.

In addition, since the MEMS microphone may include the lower anchor supporting the lower back plate and having a bent shape, and the upper anchor supporting the upper back plate and having a bent shape, the lower back plate and the upper back plate are not supported by a flat plate structure. Therefore, the flexibility of the diaphragm can be further improved without reducing rigidity of the diaphragm, the lower back plate, and the upper back plate in the MEMS microphone.

Further, the diaphragm may have the vent holes serving as passages for an acoustic wave and the etchant so that the acoustic wave can move smoothly and an efficiency of the etching process can be improved.

According to embodiments of the present invention, the lower back plate and the lower anchor are simultaneously formed, the diaphragm and the intermediate anchor are simultaneously formed, and the upper back plate and the upper anchor are simultaneously formed in the method of manufacturing the MEMS microphone. Thus process steps of manufacturing the MEMS microphone can be simplified.

In addition, while removing the lower insulation layer and the intermediate insulation layer from the vibration area and the supporting area, the lower anchor and the intermediate anchor may prevent the etchant from moving to the peripheral area. Therefore, a process margin of the MEMS microphone can be secured and a yield of the MEMS microphone can be improved.

The above summary is not intended to describe each illustrated embodiment or every implementation of the subject matter hereof. The figures and detailed description that follow more particularly exemplify various embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

Example embodiments can be understood in more detail from the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a plan view illustrating a MEMS microphone in accordance with an example embodiment of the present invention;

FIG. **2** is a cross sectional view taken along a line I-I' of FIG. **1**;

FIG. **3** is a enlarged view illustrating a portion "A" shown in FIG. **2**;

FIG. **4** is a flow chart illustrating a method of manufacturing a MEMS microphone in accordance with an example embodiment of the present invention; and

FIGS. **5** to **15** are cross sectional views illustrating a method of manufacturing a MEMS microphone in accordance with an example embodiment of the present invention.

While various embodiments are amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is not to limit the claimed inventions to the particular embodiments described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the subject matter as defined by the claims.

DETAILED DESCRIPTION OF EMBODIMENTS

Hereinafter, specific embodiments will be described in more detail with reference to the accompanying drawings. The present invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein.

As an explicit definition used in this application, when a layer, a film, a region or a plate is referred to as being 'on' another one, it can be directly on the other one, or one or more intervening layers, films, regions or plates may also be present. By contrast, it will also be understood that when a layer, a film, a region or a plate is referred to as being 'directly on' another one, it is directly on the other one, and one or more intervening layers, films, regions or plates do not exist. Also, although terms such as a first, a second, and a third are used to describe various components, compositions, regions, films, and layers in various embodiments of the present invention, such elements are not limited to these terms.

Furthermore, and solely for convenience of description, elements may be referred to as "above" or "below" one another. It will be understood that such description refers to the orientation shown in the Figure being described, and that in various uses and alternative embodiments these elements could be rotated or transposed in alternative arrangements and configurations.

In the following description, the technical terms are used only for explaining specific embodiments while not limiting the scope of the present invention. Unless otherwise defined herein, all the terms used herein, which include technical or scientific terms, may have the same meaning that is generally understood by those skilled in the art.

The depicted embodiments are described with reference to schematic diagrams of some embodiments of the present invention. Accordingly, changes in the shapes of the diagrams, for example, changes in manufacturing techniques and/or allowable errors, are sufficiently expected. The Figures are not necessarily drawn to scale. Accordingly, embodiments of the present invention are not described as being limited to specific shapes of areas described with diagrams and include deviations in the shapes and also the areas described with drawings are entirely schematic and their shapes do not represent accurate shapes and also do not limit the scope of the present invention.

FIG. **1** is a plan view illustrating a MEMS microphone in accordance with an example embodiment of the present invention, FIG. **2** is a cross sectional view taken along a line I-I' of FIG. **1**, and FIG. **3** is an enlarged view illustrating a portion "A" shown in FIG. **2**.

Referring to FIGS. **1** to **3**, a MEMS microphone **100** in accordance with an example embodiment of the present invention is capable of creating a displacement in response to an applied acoustic pressure to convert an acoustic wave into an electrical signal and output the electrical signal. The MEMS microphone **100** includes a substrate **110**, a lower back plate **120**, a diaphragm **130**, and an upper back plate **140**.

The substrate **110** may be divided into a vibration area VA, a supporting area SA surrounding the vibration area VA, and a peripheral area PA surrounding the supporting area SA. A cavity **112** is formed in the vibration area VA of the substrate **110**.

In an example embodiment, the cavity **112** may have a cylindrical shape. Further, the cavity **112** may have a shape and a size corresponding to those of the vibration area VA.

The lower back plate **120** is disposed over the substrate **110** in the vibration area VA. The lower back plate **120** may cover the cavity **112**. The lower back plate **120** may be exposed through the cavity **112**.

The lower back plate **120** may have a shape of a circular disc. A portion of the lower back plate **120** may extend through the supporting area SA to the peripheral area PA.

As shown in FIG. **3**, the lower back plate **120** may include a first lower insulation layer **120***a*, a first conductive layer **120***b*, and a first upper insulation layer **120***c*.

The first conductive layer **120***b* may be disposed between the first lower insulation layer **120***a* and the first upper insulation layer **120***c*. The first conductive layer **120***b* can be made of a silicon material such as polysilicon, and the first lower insulation layer **120***a* and the first upper insulation layer **120***c* can be made of a nitride material such as a silicon nitride.

The lower back plate **120** may have a doped portion being doped with impurities through an ion implantation process. In an example embodiment, the polysilicon, which is a material forming the first conductive layer **120***b*, may be doped with the impurities.

The lower back plate **120** may include a plurality of lower acoustic holes **122** through which the acoustic wave flow. The lower acoustic holes **122** may be formed through the lower back plate **120**.

The lower back plate **120** may include a lower anchor **124**.

The lower anchor **124** may be disposed in the supporting area SA, and support the lower back plate **120** to space the lower back plate **120** from the substrate **110**. The lower back plate **120** is bent toward the substrate **110** to form the lower anchor **124**. As shown in FIG. **2**, a lower surface of the lower anchor **120** may be in contact with an upper surface of the substrate **110** and may be fixed to the upper surface of the substrate **110**.

The lower anchor **124** may have an approximately ring shape, and may be disposed to surround the cavity **112**. In an example of embodiment, the lower anchor **124** may be integrally formed with the lower back plate **120**. The lower anchor **124** may have a U-shaped vertical section.

The diaphragm **130** may be disposed over the lower back plate **120** and spaced apart from the lower back plate **120**. The diaphragm **130** may have a membrane structure. The diaphragm **130** may generate a displacement due to an applied acoustic pressure. Since the diaphragm **130** is spaced apart from the lower back plate **120**, the diaphragm **130** may vibrate due to the acoustic pressure.

The diaphragm **130** may be made of a silicon material such as polysilicon. The diaphragm **130** may have a doped portion being doped with impurities through an ion implantation process.

The diaphragm **130** may have a shape of a circular disc. A portion of the diaphragm **130** may extend through the supporting area SA to the peripheral area PA.

The diaphragm **130** may include an intermediate anchor **136**.

The intermediate anchor **136** may be disposed in the supporting area SA, and support the diaphragm **130** to space the diaphragm **130** from the lower back plate **120**. The diaphragm **130** is bent toward the lower back plate **120** to form the intermediate anchor **136**. A lower surface of the intermediate anchor **136** may be in contact with an upper surface of the lower back plate **120** and may be fixed to the upper surface of the lower back plate **120**.

The intermediate anchor **136** may be arranged along a periphery of the diaphragm **130**, and have an approximately ring shape. In an example of embodiment, the intermediate anchor **136** may be integrally formed with the diaphragm **130**. The intermediate anchor **136** may have a U-shaped vertical section.

The diaphragm **130** may have a plurality of first vent holes **132** and a plurality of second vent holes **134**.

Each of the first vent holes **132** and the second vent holes **134** may be disposed inside of the intermediate anchor **136** in a horizontal direction. The each of the first vent holes **132** and the second vent holes **134** may be arranged along the intermediate anchor **136** in a ring shape and may be spaced apart from each another. The first vent holes **132** and the second vent holes **134** are formed by penetrating through the diaphragm **130** in a vertical direction.

Each of the first vent holes **132** may serve as a passage for the acoustic wave. Further, each of the first vent holes **132** may also function as a passage for an etchant to be used in a process of manufacturing the MEMS microphone **100**. Each of the second vent holes **134** may serve as a passage for the acoustic wave. Further, each of the second vent holes **134** may mainly function as a passage for the etchant to be used in the process of manufacturing the MEMS microphone **100**.

The second vent holes **134** are located outside of the first vent holes **132** in the horizontal direction. In an example of embodiment, the first vent holes **132** may be located inside of the lower anchor **124** and the second vent holes **134** may be located outside of the lower anchor **124**.

The first vent holes **132** and the second vent holes **134** may be positioned in the vibration area VA. Alternatively, the first vent holes **132** and the second vent holes **134** may be positioned in a boundary area between the vibration area VA and the supporting area SA or in the supporting area SA adjacent to the vibration area VA.

The diaphragm **130** may include lower dimples **138**. The lower dimples **138** may protrude from a lower surface of the diaphragm **130** toward the lower back plate **120**. Thus, the lower dimples **138** can prevent the diaphragm **130** from being coupled to the upper surface of the lower back plate **120**.

Particularly, when the acoustic pressure is applied to the diaphragm **130**, the diaphragm **120** can be bent in a generally semispherical or paraboloid shape toward the lower back plate **120** or the upper back plate **140**, and then can return to its initial position. The degree of bending of the diaphragm **130** may vary depending on a magnitude of the applied acoustic pressure. Even if the diaphragm **130** is bent so much as to contact the lower back plate **120**, the lower dimples **138** may keep the diaphragm **130** and the lower back plate **120** sufficiently separated from each other that the diaphragm **130** is able to return to the initial position.

The upper back plate **140** may be disposed over the diaphragm **130** to be spaced apart from the diaphragm **130**.

The upper back plate **140** may be disposed in the vibration area VA, the supporting area SA, and the peripheral area PA.

As shown in FIG. **3**, the upper back plate **140** may include a second lower insulation layer **140***a*, a second conductive layer **140***b*, and a second upper insulation layer **140***c*.

The second conductive layer **140***b* may be disposed between the second lower insulation layer **140***a* and the second upper insulation layer **140***c*. The second conductive layer **140***b* can be made of a silicon material such as polysilicon, and the second lower insulation layer **140***a* and the second upper insulation layer **140***c* can be made of a nitride material such as a silicon nitride.

The upper back plate **140** may have a doped portion being doped with impurities through an ion implantation process. In an example embodiment, the polysilicon, which is a material forming the second conductive layer **140***b*, may be doped with the impurities.

The second upper insulation layer **140***c* may include a pair of protrusion portions **141** protruding from a lower surface of the upper insulation layer **140***c* and penetrating the second conductive layer **140***b* to make contact with the second lower insulation layer **140***a*. The protrusion portions **141** may have a ring shape, and may be disposed in the supporting area SA and the peripheral area PA.

The protrusion portions **141** may divide the second conductive layer **140***b* into an inner area, an intermediate area surrounding the inner area, and an outer area surrounding the intermediate area. A portion of the inner area of the second conductive layer **140***b* may extend to the peripheral area PA.

In an example embodiment, the inner area may be a conductive area in which impurities are doped, and the outer area may be a non-conductive area in which the impurities are not doped. Alternatively, both the inner area and the outer area may be conductive areas.

The upper back plate **140** may include an upper anchor **144**.

The upper anchor **144** may be disposed in the supporting area SA, and support the upper back plate **140** to space the upper back plate **140** from the diaphragm **130**. The upper back plate **140** is bent toward the diaphragm **130** to form the upper anchor **144**. As shown in FIG. **2**, a lower surface of the upper anchor **120** may be in contact with an upper surface of the diaphragm **130** and may be fixed to the upper surface of the diaphragm **130**.

The upper anchor **144** may have an approximately ring shape, and may be disposed along a circumference of the upper back plate **140**. In an example embodiment, the upper anchor **144** may be integrally formed with the upper back plate **140**. The upper anchor **144** may have a U-shaped vertical section.

The upper back plate **140** may include upper dimples **146**. The upper dimples **146** may protrude from a lower surface of the upper back plate **140** toward the lower back plate **120**. Thus, the upper dimples **146** can prevent the upper back plate **140** from being entirely in contact with or permanently/semi-permanently coupled to the upper surface of the lower back plate **120** by reducing the contact area between those two components.

Particularly, even if the diaphragm **130** is bent so much as to contact the upper back plate **140**, the upper dimples **146** may keep the diaphragm **130** and the upper back plate **140** sufficiently separated from each other that the diaphragm **130** is able to return to the initial position.

Since the upper back plate **140** is also disposed in the peripheral area PA, the upper back plate **140** is stably supported by an upper insulation layer **170** described later. Therefore, sagging of the upper back plate **140** may be prevented.

In an example embodiment, the MEMS microphone **100** may further include a lower insulation layer **150**, an intermediate insulation layer **160**, the upper insulation layer **170**, a lower electrode **182**, an intermediate electrode **184**, and an upper electrode **186**.

In embodiments, the lower insulation layer **150** may be disposed on the upper surface of the substrate **110** and may support the lower back plate **120**. The lower insulation layer **150** is positioned in the peripheral area PA and the supporting area SA. Specifically, the lower insulation layer **150** may be located outside of the lower anchor **124** in the horizontal direction.

The intermediate insulation layer **160** may be disposed on an upper surface of the lower insulation layer **150** and may support the diaphragm **130**. The intermediate insulation layer **160** is positioned in the peripheral area PA and the supporting area SA. Specifically, the intermediate insulation layer **160** may be located outside of the intermediate anchor **136** in the horizontal direction.

The upper insulation layer **170** may be disposed on an upper surface of the intermediate insulation layer **160** and may support the upper back plate **140**. The upper insulation layer **170** is positioned in the peripheral area PA and the supporting area SA. Specifically, the upper insulation layer **170** may be located outside of the upper anchor **144** in the horizontal direction.

The lower electrode **182** may be disposed in the peripheral area PA and penetrates through the upper back plate **140**, the upper insulation layer **170**, and the intermediate insulation layer **160** to make electrically contact with the lower back plate **120**. Specifically, the lower electrode **182** may make contact with the portion of the lower back plate **120** extending to the peripheral area PA. The lower electrode **182** may penetrate through the first upper insulation layer **120*c*** to make contact with the first conductive layer **120*b***.

The intermediate electrode **184** may be disposed in the peripheral area PA and penetrates through the upper back plate **140** and the upper insulation layer **170** to make electrically contact with the diaphragm **130**. Specifically, the intermediate electrode **184** may make contact with the portion of the diaphragm **130** extending to the peripheral area PA.

The upper electrode **186** may be disposed in the peripheral area PA and make electrically contact with the upper back plate **140**. Specifically, the upper electrode **186** may make contact with the portion of the inner area of the second conductive layer **140*b*** extending to the peripheral area PA. The upper electrode **186** may penetrate through the second upper insulation layer **140*c*** to make contact with the second conductive layer **140*b***.

In addition, the lower electrode **182** makes contact with the intermediate area of the second conductive layer **140*b*** while passing through the intermediate area, the intermediate electrode **184** makes contact with the outer area of the second conductive layer **140*b*** while passing through the outer area, and the upper electrode **186** makes contact with the inner area of the second conductive layer **140*b***. Alternatively, no shown in detail in figures, the lower electrode **182** makes contact with the outer area of the second conductive layer **140*b*** while passing through the outer area, the intermediate electrode **184** makes contact with the intermediate area of the second conductive layer **140*b*** while passing through the intermediate area, and the upper electrode **186** makes contact with the inner area of the second conductive layer **140*b***.

Since the lower electrode **182**, the intermediate electrode **184**, and the upper electrode **186** make in contact with different areas of the inner area, the intermediate area, and the outer area of the second conductive layer **140*b***, the lower electrode **182**, the intermediate electrode **184**, and the upper electrode **186** are not electrically connected to each other by the second conductive layer **140*b***.

As described above, the MEMS microphone **100** includes the intermediate anchor **134** supporting the diaphragm **130** and having a bent shape so that the diaphragm **130** can be elastically supported by the intermediate anchor **134**. Since flexibility of the diaphragm **130** can be remarkably improved without reducing rigidity of the diaphragm **130** as compared with conventional MEMS microphone, sensitivity of the diaphragm **130** can be improved and the sagging of the diaphragm **130** can be prevented.

Also, since the MEMS microphone **100** may include the lower anchor **124** supporting the lower back plate **120** and having a bent shape, and the upper anchor **144** supporting the upper back plate **140** and having a bent shape, the lower back plate **120** and the upper back plate **140** are not supported by a flat plate structure. Therefore, the flexibility of the diaphragm **130** can be further improved without reducing the rigidity of the diaphragm **130**, the lower back plate **120**, and the upper back plate **140** in the MEMS microphone **100**.

In addition, the lower anchor **124**, the intermediate anchor **136**, and the upper anchor **144** have a ring shape to make contact with the substrate **110**, the lower back plate **120**, and the vibration plate **130**, respectively. Therefore, the lower anchor **124**, the intermediate anchor **136**, and the upper anchor **144** may block movement of the etchant for removing the lower insulation layer **150**, the intermediate insulation layer **160**, and the upper insulation layer **170** into the peripheral area PA.

Further, the diaphragm **130** may have the first vent holes **132** and the second vent holes **134** serving as passages for an acoustic wave and the etchant so that the acoustic wave can move smoothly and an efficiency of the etching process can be improved.

Hereinafter, a method of manufacturing a MEMS microphone will be described in detail with reference to the drawings.

FIG. **4** is a flow chart illustrating a method of manufacturing a MEMS microphone in accordance with an example embodiment of the present invention, and FIGS. **5** to **15** are cross sectional views illustrating a method of manufacturing a MEMS microphone in accordance with an example embodiment of the present invention.

Referring to FIGS. **4** and **5**, according to example embodiments of a method for manufacturing a MEMS microphone, a lower insulation layer **150** is formed on a substrate **110** at **S110**.

The lower insulation layer **150** may be formed by a deposition process, and the lower insulation layer **150** may be made of an oxide such as silicon oxide or TEOS.

Referring to FIGS. **4** and **6**, a lower back plate **120**, lower acoustic holes **122**, and a lower anchor **124** are formed on the lower insulation layer **150** at S**120**.

Hereinafter, the S**120** for forming the lower back plate **120**, the lower acoustic holes **122**, and the lower anchor **124** will described in detail as follows.

First, a lower anchor channel for forming the lower anchor **124** is formed by patterning the lower insulation layer **150** through an etching process. Here, the lower anchor channel may partially expose the substrate **110**. The lower anchor channel may be formed in the supporting area SA on the substrate **110**. In an example embodiment, the lower anchor channel may be formed to have a ring shape to surround the vibration area VA.

Next, a first lower insulation layer **120***a*, a first conductive layer **120***b*, and a first upper insulation layer **120***c* are sequentially deposited on the lower insulation layer **150** on which the lower anchor channel is formed. In an example embodiment, the first conductive layer **120***b* is made of a silicon material such as polysilicon, and the first lower insulation layer **120***a* and the first upper insulation layer **120***c* are made of a nitride such as silicon nitride.

After depositing the first conductive layer **120***b*, impurities may be doped into the first conductive layer **120***b* through an ion implantation process.

Then, the first lower insulation layer **120***a*, the first conductive layer **120***b*, and the first upper insulation layer **120***c* are patterned through an etching process to form the lower back plate **120**, the lower acoustic holes **122**, and the lower anchor **124**.

The lower back plate **120** may have a shape of a circular disc. A portion of the lower back plate **120** may extend to the peripheral area PA.

The lower acoustic holes **122** may be located in the vibration area SA and may penetrate the lower back plate **120**.

The lower anchor **124** may be located in the supporting area SA and may have a ring shape. The lower anchor **124** may be disposed along a circumference of the lower back plate **120**.

Referring to FIGS. **4** and **7**, an intermediate insulation layer **160** is formed on the lower insulation layer **150** on which the lower back plate **120**, the lower acoustic holes **122**, and the lower anchor **124** are formed at S**130**.

The intermediate insulation layer **160** may be formed by a deposition process. The intermediate insulation layer **160** may be made of the same material as that of the lower insulation layer **150**. The intermediate insulation layer **160** may be made of an oxide such as silicon oxide or TEOS.

Then, the intermediate insulation layer **160** is patterned through an etching process to form an intermediate anchor channel **162** in the supporting area SA. Here, the intermediate anchor channel **162** may partially expose the lower back plate **120**. The intermediate anchor channel **162** may be formed to have a ring shape to surround the lower back plate **120**.

In addition, lower dimple holes **164** for forming lower dimples **138** (see FIG. **2**) are formed by patterning the intermediate insulation layer **160** through an etching process. The lower dimple holes **164** may be formed in the vibration area VA. The intermediate insulation layer **160** may be partially etched so that the lower dimples **138** protrude from a lower surface of a diaphragm **130** toward the lower back plate **120**.

Referring to FIGS. **4** and **8**, a diaphragm **130** and an intermediate anchor **136** are formed on the intermediate insulation layer **160** on which the intermediate anchor channel **162** and the lower dimple holes **164** are formed at S**140**.

Hereinafter, the S**140** for forming the diaphragm **130** and the intermediate anchor **136** will be described in detail as follows.

First, a silicon layer is deposited on the intermediate insulation layer **160** on which the intermediate anchor channel **162** and the lower dimple holes **164** are formed. In an example embodiment, the silicon layer may be made of polysilicon.

Next, impurities are doped into the silicon layer through an ion implantation process.

Then, the silicon layer is patterned through an etching process to form the diaphragm **130** and the intermediate anchor **136**.

The diaphragm **130** may have a shape of a circular disc. A portion of the diaphragm **130** may extend to the peripheral area PA.

The intermediate anchor **136** may be located in the supporting area SA and may have a ring shape. The intermediate anchor **136** may be disposed along a circumference of the diaphragm **130**.

The lower dimples **138** are formed on the lower dimple holes **164** by depositing the silicon layer.

First vent holes **132** and second vent holes **134** may also be formed on the diaphragm **130**. The first vent holes **132** and the second vent holes **134** may be positioned in the vibration area VA. Alternatively, the first vent holes **132** and the second vent holes **134** may be positioned in a boundary area between the vibration area VA and the supporting area SA or in the supporting area SA adjacent to the vibration area VA.

The second vent holes **134** are located outside of the first vent holes **132** in the horizontal direction. In an example of embodiment, the first vent holes **132** may be located inside of the lower anchor **124** and the second vent holes **134** may be located outside of the lower anchor **124**.

Referring to FIGS. **4** and **9**, an upper insulation layer **170** is formed on the intermediate insulation layer **160** on which the diaphragm **130** and the intermediate anchor **136** are formed at S**150**.

The upper insulation layer **170** may be formed by a deposition process. The upper insulation layer **170** may be made of the same material as that of the lower insulation layer **150**. The upper insulation layer **170** may be formed of an oxide such as silicon oxide or TEOS.

Then, the upper insulation layer **170** is patterned through an etching process to form an upper anchor channel **172** in the supporting area SA. Here, the upper anchor channel **172** may partially expose the diaphragm **130**. The upper anchor channel **172** may be formed to have a ring shape to surround the diaphragm **130**.

In addition, upper dimple holes **174** for forming upper dimples **146** (see FIG. **2**) are formed by patterning the upper insulation layer **170** through an etching process. The upper dimple holes **174** may be formed in the vibration area VA. The upper insulation layer **170** may be partially etched so that the upper dimples **146** protrude from a lower surface of an upper back plate **140** toward the diaphragm **130**.

Referring to FIGS. **4** and **10**, the upper back plate **140** and an upper anchor **144** are formed on the upper insulation layer **170** on which the upper anchor channel **172** and the upper dimple holes **174** are formed at S**160**.

Hereinafter, the S**160** for forming the upper back plate **140** and the upper anchor **144** will be described in detail as follows.

First, a second lower insulation layer **140***a* and a second conductive layer **140***b* are sequentially deposited on the upper insulation layer **170** on which the upper anchor channel **172** and the upper dimple holes **174** are formed. In an example embodiment, the second conductive layer **140***b* may be made of a silicon material such as polysilicon, and the second lower insulation layer **140***a* may be made of a nitride such as silicon nitride. Here, the second lower insulation layer **140***a* and the second conductive layer **140***b* are formed in the vibration area VA, the supporting area SA, and the peripheral area PA.

Then, the second conductive layer **140***b* is patterned through an etching process to form a pair of protrusion channels partially exposing the second lower insulation layer **140***a*. The protrusion channels may have a ring shape, and may be disposed in the supporting area SA and the peripheral area PA.

The protrusion channels may divide the second conductive layer **140***b* into an inner area, an intermediate area surrounding the inner area, and an outer area surrounding the intermediate area. A portion of the inner area of the second conductive layer **140***b* may extend to the peripheral area PA.

In addition, impurities may be doped into the second conductive layer **140***b* through an ion implantation process. The impurity may be doped only in the inner area. Alternatively, the impurity may be doped in both the inner area and the outer area may be doped.

Then, a second upper insulation layer **140***c* is deposited on the second conductive layer **140***b* on which the protrusion channels is formed. In an example embodiment, the second upper insulation layer **140***c* may be made of a nitride such as silicon nitride.

A pair of protrusion portions **141** may be formed in the protrusion channels. The protrusion portions **141** may protrude from a lower surface of the upper insulation layer **140***c* and penetrate through the second conductive layer **140***b* to make contact with the second lower insulation layer **140***a*. The protrusions **141** may divide the second conductive layer **140***b* into the inner area, the intermediate area, and the outer area.

The upper back plate **140** and the upper anchor **144** are formed by depositing the second lower insulation layer **140***a*, the second conductive layer **140***b*, and the second upper insulation layer **140***c*.

The upper back plate **140** is disposed in the vibration area VA, the supporting area SA, and the peripheral area PA. Since the upper back plate **140** is stably supported by the upper insulation layer **170**, sagging of the upper back plate **140** can be prevented.

The upper anchor **144** is located in the supporting area SA, and may have a ring shape. The upper anchor **144** may be disposed along a circumference of the diaphragm **130**.

The upper dimples **146** are formed on the upper dimple holes **174** by depositing the second lower insulation layer **140***a*.

Referring to FIGS. **4**, **11**, and **12**, the intermediate insulation layer **160**, the upper insulation layer **170**, and the upper back plate **140** are patterned to form a lower electrode **182**, an intermediate electrode **184**, and an upper electrode **186** at S**170**.

Hereinafter, the S**170** for forming the lower electrode **182**, the intermediate electrode **184**, and the upper electrode **186** will be described in detail as follows.

The upper back plate **140**, the upper insulation layer **170**, the intermediate insulation layer **160**, and the first upper insulation layer **120***c* are patterned in the peripheral area PA to form the first electrode hole CH**1**. The first electrode hole CH**1** exposes the first conductive layer **120***b* at the portion of the lower back plate **120** extending to the peripheral area PA.

The upper back plate **140** and the intermediate insulation layer **160** are patterned in the peripheral area PA to form a second electrode hole CH**2**. The second electrode hole CH**2** exposes the portion of the diaphragm **130** extending to the peripheral area PA

The second upper insulation layer **140***c* is patterned on the upper back plate **140** in the peripheral area PA to form a third electrode hole CH**3**. The third electrode hole CH**3** exposes the portion of the inner area of the second conductive layer **140***b* extending to the peripheral area PA.

The lower electrode **182** makes contact with the intermediate area of the second conductive layer **140***b* while passing through the intermediate area, the intermediate electrode **184** makes contact with the outer area of the second conductive layer **140***b* while passing through the outer area, and the upper electrode **186** makes contact with the inner area of the second conductive layer **140***b*. Alternatively, in an embodiment not shown in detail in figures, the lower electrode **182** makes contact with the outer area of the second conductive layer **140***b* while passing through the outer area, the intermediate electrode **184** makes contact with the intermediate area of the second conductive layer **140***b* while passing through the intermediate area, and the upper electrode **186** makes contact with the inner area of the second conductive layer **140***b*.

Next, a thin film (not shown in detail in figures) is deposited on the upper back plate **140** on which the first electrode hole CH**1**, the second electrode hole CH**2**, and the third electrode hole CH**3** are formed. Here, the thin film may be made of a conductive metal material.

The thin film is patterned to form the lower electrode **182**, the intermediate electrode **184**, and the upper electrode **186**. Accordingly, the lower electrode **182** may be disposed in the peripheral area PA and penetrates through the upper back plate **140**, the upper insulation layer **170**, the intermediate insulation layer **160**, and the first upper insulation layer **120***c* to make electrically contact with the first conductive layer **120***b*. The intermediate electrode **184** may be disposed in the peripheral area PA and penetrates through the upper back plate **140** and the upper insulation layer **170** to make electrical contact with the diaphragm **130**. The upper electrode **186** may be disposed in the peripheral area PA and penetrate through the second upper insulation layer **140***c* to make electrical contact with the inner area of the second conductive layer **140***b*.

In addition, since the lower electrode **182**, the intermediate electrode **184**, and the upper electrode **186** make in contact with different areas of the inner area, the intermediate area, and the outer area of the second conductive layer **140***b*, The lower electrode **182**, the intermediate electrode **184**, and the upper electrode **186** are not electrically connected to each other by the second conductive layer **140***b*.

Referring to FIGS. **4** and **13**, the upper back plate **140** is patterned to form upper acoustic holes **142** at S**180**.

The upper acoustic holes **142** are disposed in the vibration area SA and may penetrate through the upper back plate **140**.

Referring to FIGS. **4** and **14**, after forming the upper acoustic holes **142**, the substrate **110** is patterned to form a cavity **112** in the vibration area VA at S**190**.

Here, the lower insulation layer **150** is partially exposed through the cavity **112**.

Referring to FIGS. **4** and **15**, the lower insulation layer **150**, the intermediate insulation layer **160**, and the upper insulation layer **170** are removed in the vibration area VA and the supporting area SA through an etching process using the cavity **112**, the lower acoustic holes **122**, the first vent holes **132**, the second vent holes **134**, and the upper acoustic holes **142** at S**190**.

As a result, the lower back plate **120** is exposed through the cavity **112**, and an air gap is formed both between the diaphragm **130** and the lower back plate **120**, and between the diaphragm **130** and the upper back plate **140**. Here, the cavity **112**, the lower acoustic holes **122**, the first vent holes **132**, the second vent holes **134**, and the upper acoustic holes **142** may serve as passages of etchant for removing the lower insulation layer **150**, The intermediate insulation layer **160** and the upper insulation layer **170**.

In particular, the lower anchor **124**, the intermediate anchor **136**, and the upper anchor **144** may block movement of the etchant during removing the lower insulation layer **150**, the intermediate insulation layer **160**, and the upper insulation layer **170** in the vibration area VA and the supporting area SA at the S**190**. Accordingly, it is easy to control an etching amount of the lower insulation layer **150**, the intermediate insulation layer **160** and the upper insulation layer **170**.

In an example embodiment hydrogen fluoride vapor (HF vapor) may be used as an etchant for removing the lower insulation layer **150**, the intermediate insulation layer **160**, and the upper insulation layer **170**.

As described above, the lower back plate **120** and the lower anchor **124** are simultaneously formed, the diaphragm **130** and the intermediate anchor **136** are simultaneously formed, and the upper back plate **140** and the upper anchor **144** are simultaneously formed in the method of manufacturing the MEMS microphone. Thus the process of manufacturing the MEMS microphone can be simplified.

In addition, while removing the lower insulation layer **150**, the intermediate insulation layer **160**, and the upper insulation layer **170** in the vibration area and the supporting area, the lower anchor **124**, the intermediate anchor **136**, and the upper anchor **144** may prevent the etchant from moving to the peripheral area PA. Therefore, a process margin of the MEMS microphone can be secured and a yield of the MEMS microphone can be improved.

Further, since the etchant may also move through the first vent holes **132** and the second vent holes **134** of the diaphragm **130**, efficiency of the etching process may be improved.

Although the MEM microphone has been described with reference to the specific embodiments, they are not limited thereto. Therefore, it will be readily understood by those skilled in the art that various modifications and changes can be made thereto without departing from the spirit and scope of the appended claims.

Various embodiments of systems, devices and methods have been described herein. These embodiments are given only by way of example and are not intended to limit the scope of the invention. It should be appreciated, moreover, that the various features of the embodiments that have been described may be combined in various ways to produce numerous additional embodiments. Moreover, while various materials, dimensions, shapes, configurations and locations, etc. have been described for use with disclosed embodiments, others besides those disclosed may be utilized without exceeding the scope of the invention.

Persons of ordinary skill in the relevant arts will recognize that the invention may comprise fewer features than illustrated in any individual embodiment described above. The embodiments described herein are not meant to be an exhaustive presentation of the ways in which the various features of the invention may be combined. Accordingly, the embodiments are not mutually exclusive combinations of features; rather, the invention can comprise a combination of different individual features selected from different individual embodiments, as understood by persons of ordinary skill in the art. Moreover, elements described with respect to one embodiment can be implemented in other embodiments even when not described in such embodiments unless otherwise noted. Although a dependent claim may refer in the claims to a specific combination with one or more other claims, other embodiments can also include a combination of the dependent claim with the subject matter of each other dependent claim or a combination of one or more features with other dependent or independent claims. Such combinations are proposed herein unless it is stated that a specific combination is not intended. Furthermore, it is intended also to include features of a claim in any other independent claim even if this claim is not directly made dependent to the independent claim.

Any incorporation by reference of documents above is limited such that no subject matter is incorporated that is contrary to the explicit disclosure herein. Any incorporation by reference of documents above is further limited such that no claims included in the documents are incorporated by reference herein. Any incorporation by reference of documents above is yet further limited such that any definitions provided in the documents are not incorporated by reference herein unless expressly included herein.

For purposes of interpreting the claims for the present invention, it is expressly intended that the provisions of Section 112(f) of 35 U.S.C. are not to be invoked unless the specific terms "means for" or "step for" are recited in a claim.

What is claimed is:

1. A Micro-Electro-Mechanical Systems (MEMS) microphone comprising:

a substrate presenting a vibration area, a supporting area surrounding the vibration area, and a peripheral area surrounding the supporting area, the substrate defining a cavity formed in the vibration area;

a lower back plate being disposed over the substrate to cover the cavity and having a plurality of lower acoustic holes;

a diaphragm being disposed over the lower back plate, the diaphragm being spaced apart from the lower back plate and configured to generate a displacement thereof in response to an applied acoustic pressure;

an upper back plate being disposed over the diaphragm, the upper back plate being spaced apart from the diaphragm and having a plurality of upper acoustic holes; and

an intermediate anchor being in contact with an upper surface of the lower back plate in the supporting area, the intermediate anchor being configured to support the diaphragm to space the diaphragm from the lower back plate, and to provide elasticity for the diaphragm,

wherein the intermediate anchor has a U-shaped vertical section to be in contact with an upper surface of the lower back plate.

2. The MEMS microphone of claim **1**, further comprising:

a lower anchor being in contact with an upper surface of the substrate in the supporting area, the lower anchor being configured to support the lower back plate to space the lower back plate apart from the substrate; and

an upper anchor being in contact with an upper surface of the diaphragm in the supporting area, the upper anchor being configured to support the upper back plate to space the upper back plate apart from the diaphragm.

3. The MEMS microphone of claim **2**, further comprising:

a lower insulation layer disposed on the upper surface of the substrate and outside of the lower anchor, and being configured to support the lower back plate;

an intermediate insulation layer disposed on an upper surface of the lower insulation layer and outside of the intermediate anchor, and being configured to support the diaphragm; and

a upper insulation layer disposed on an upper surface of the intermediate insulation layer and outside of the upper anchor, and being configured to support the upper back plate.

4. The MEMS microphone of claim 3, further comprising:

a lower electrode penetrating through the upper insulation layer and the intermediate insulation layer and being disposed in the peripheral area to make electrical contact with the lower back plate;

an intermediate electrode penetrating through the upper insulation layer and being disposed in the peripheral area to make electrical contact with the diaphragm; and

an upper electrode disposed in the peripheral area and making electrical contact with the upper back plate.

5. The MEMS microphone of claim 4, wherein each of the lower back plate and the upper back plate includes a conductive layer and insulation layers disposed on an upper surface and a lower surface of the conductive layer.

6. The MEMS microphone of claim 5, wherein the upper insulation layer included in the upper back plate includes a pair of protrusion portions protruding from a lower surface of the upper insulation layer and penetrating through the conductive layer to make contact with the lower insulation layer included in the upper back plate, and

wherein the protrusion portions divide the conductive layer into an inner area, an intermediate area surrounding the inner area, and an outer area surrounding the intermediate area.

7. The MEMS microphone of claim 6, wherein the lower electrode makes contact with the intermediate area of the conductive layer, the intermediate electrode makes contact with the outer area of the conductive layer, and the upper electrode makes contact with the inner area of the conductive layer.

8. The MEMS microphone of claim 1, wherein the diaphragm defines a plurality of vent holes penetrating therethrough and spaced apart from each other to be arranged along a periphery of the diaphragm.

9. The MEMS microphone of claim 1, further comprising:

lower dimples protruding from a lower surface of the diaphragm toward the lower back plate and preventing the diaphragm from being coupled to the lower back plate; and

upper dimples protruding from a lower surface of the upper back plate toward the diaphragm and preventing the upper back plate from being coupled to the diaphragm.

10. A method of manufacturing a MEMS microphone, comprising:

forming a lower insulation layer on a substrate, the substrate having a vibration area, a supporting area surrounding the vibration area, and a peripheral area surrounding the supporting area;

forming a lower back plate having a plurality of lower acoustic holes on the lower insulation layer;

forming an intermediate insulation layer on the lower insulation layer on which the lower back plate is formed;

forming a diaphragm and an intermediate anchor being configured to support the diaphragm on the intermediate insulation layer, respectively;

forming an upper insulation layer on the intermediate insulation layer on which the diaphragm and the intermediate anchor are formed; and

forming a upper back plate having a plurality of upper acoustic holes on the upper insulation layer.

11. The method of claim 10, wherein forming the lower back plate includes forming a lower anchor being configured to support the lower back plate simultaneously, and

wherein forming the upper back plate includes forming an upper anchor being configured to support the upper back plate simultaneously.

12. The method of claim 11, wherein the lower anchor, the intermediate anchor and the upper anchor are disposed in the supporting area, and

wherein the lower anchor is in contact with an upper surface of the substrate, the intermediate anchor is in contact with an upper surface of the lower back plate, and the upper anchor is in contact with an upper surface of the diaphragm.

13. The method of claim 10, further comprising:

after forming the upper back plate,

forming a lower electrode, an intermediate electrode, and an upper electrode in the peripheral area, and

wherein the lower electrode penetrates through the upper insulation layer and the intermediate insulation layer to make electrical contact with the lower back plate, the intermediate electrode penetrates through the upper insulation layer to make electrical contact with the diaphragm, and the upper electrode makes electrical contact with the lower upper back plate.

14. The method of claim 13, wherein each of the lower back plate and the upper back plate includes a conductive layer and insulation layers disposed on an upper surface and a lower surface of the conductive layer.

15. The method of claim 14, wherein the upper insulation layer included in the upper back plate includes a pair of protrusion portions protruding from a lower surface of the upper insulation layer and penetrating through the conductive layer to make contact with the lower insulation layer included in the upper back plate, and

wherein the protrusion portions divide the conductive layer into an inner area, an intermediate area surrounding the inner area, and an outer area surrounding the intermediate area.

16. The method of claim 15, wherein the lower electrode makes contact with the intermediate area of the conductive layer, the intermediate electrode makes contact with the outer area of the conductive layer, and the upper electrode makes contact with the inner area of the conductive layer.

17. The method of claim 13, further comprising:

after forming the lower electrode, the intermediate electrode, and the upper electrode,

patterning the upper back plate to form upper acoustic holes penetrating the back plate;

patterning the substrate to form a cavity exposing the lower insulation layer to the vibration area; and

performing an etching process using the cavity, the lower acoustic holes, and the upper acoustic holes to remove portions of the lower insulation layer and the intermediate insulation layer, located at positions corresponding the vibration area and the supporting area so that the diaphragm is bendable by acoustic pressure.

18. The method of claim 17, wherein forming the diaphragm and the intermediate anchor includes forming a plurality of vent holes penetrating through the diaphragm simultaneously with the diaphragm and the intermediate anchor, and

wherein the vent holes are formed on the vibration area.

19. The method of claim **18**, wherein the vent holes serve as passages for an etchant to remove the portions of the lower insulation layer and the intermediate insulation layer during the etching process.

* * * * *